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(54) Abstract Title
Fuel injection method and system for i.c. engines

(57) A method of injecting fuel at at least two different high fuel pressures via injectors 8 into the combustion chamber of an i.c. engine, wherein the higher fuel pressure is stored in a central pressure storage device (common rail) 6, the lower fuel pressure being produced during the injection procedure on each occasion locally at each injector individually by reducing the higher fuel pressure under the control of a directional control valve 9. In figure 1a, an accumulator chamber 26 is filled with fuel at the higher pressure, eg 1200 bar, during a main injection. Then, by switching the 3 port, 2 position directional control valve 9, the main injection is terminated and pressure line 10 is connected to a leakage line 25 via a pressure-limiting valve 27 set to the lower pressure, eg 300 bar. The pressure-limiting valve 27 may be located outside the injector housing (fig.1b). The higher pressure in common rail 6 may be generated by a pressure intensifier (33, fig.2) from a lower pressure common rail (31). A modification (fig.3) has no accumulator chamber; instead, a directional control valve (52) switches through the higher pressure fuel in common rail 6 or shuts the flow off in a dissipative manner by means of a restrictor (53) and a pressure-limiting valve (55) set to the lower pressure. The invention enables the lower pressure fuel to be metered in an improved manner.

Fig. 1a

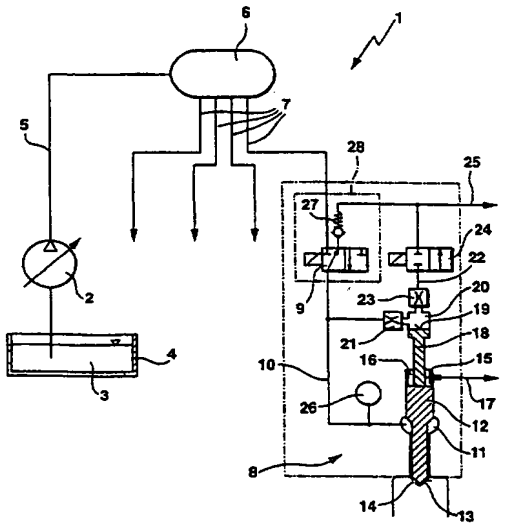

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Fig. 1a

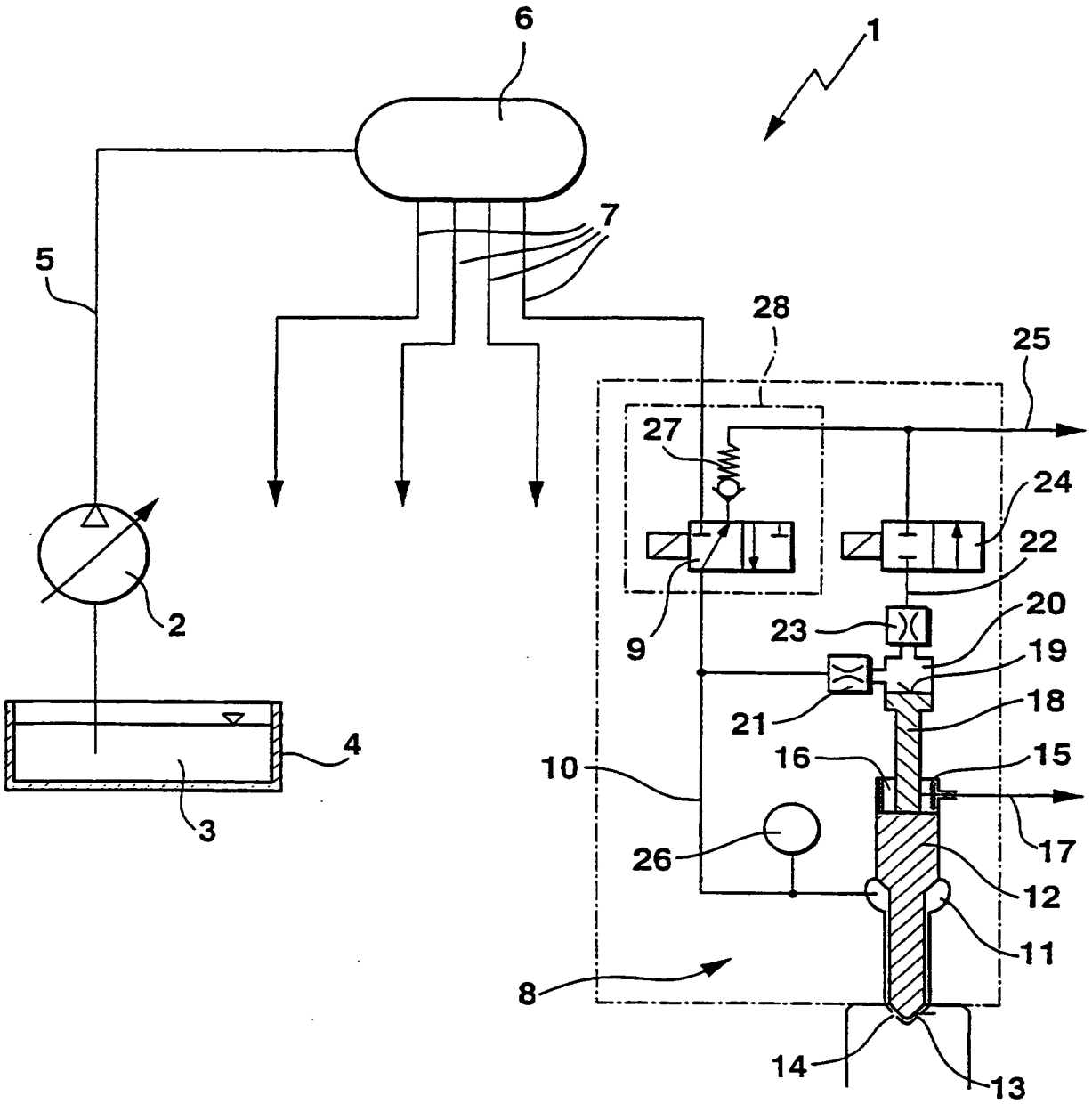


Fig. 1b

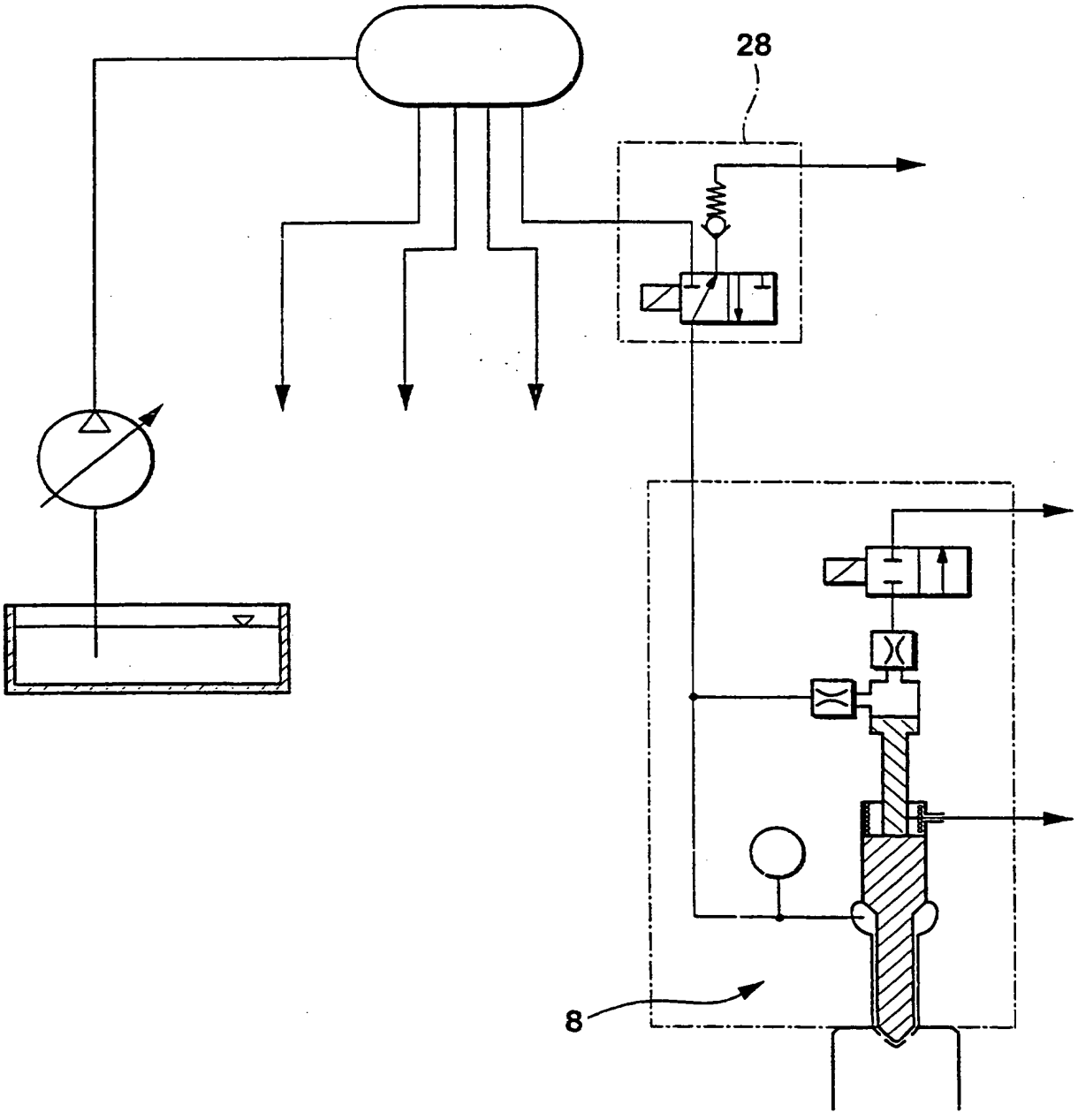


Fig. 2

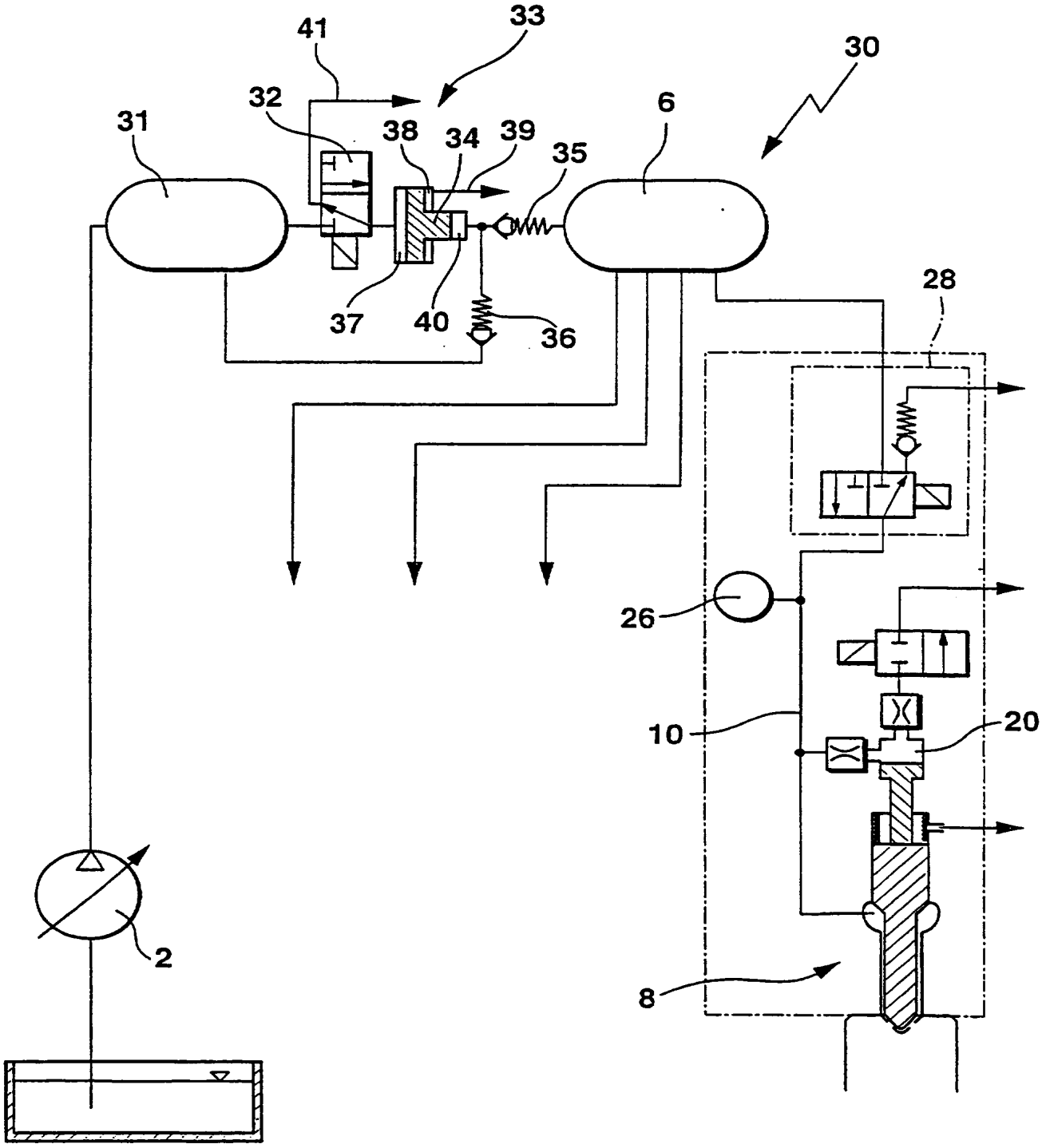


Fig. 3

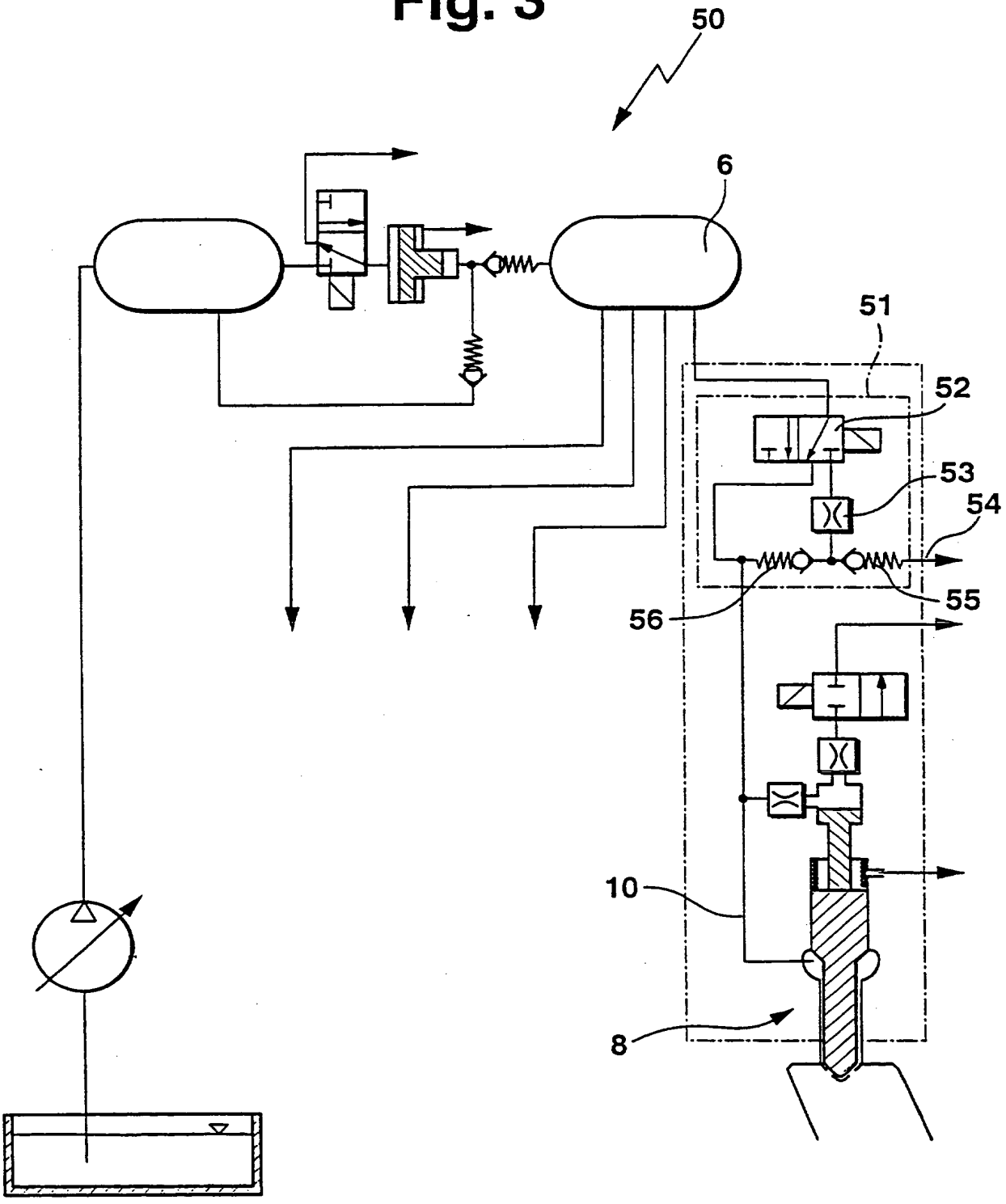
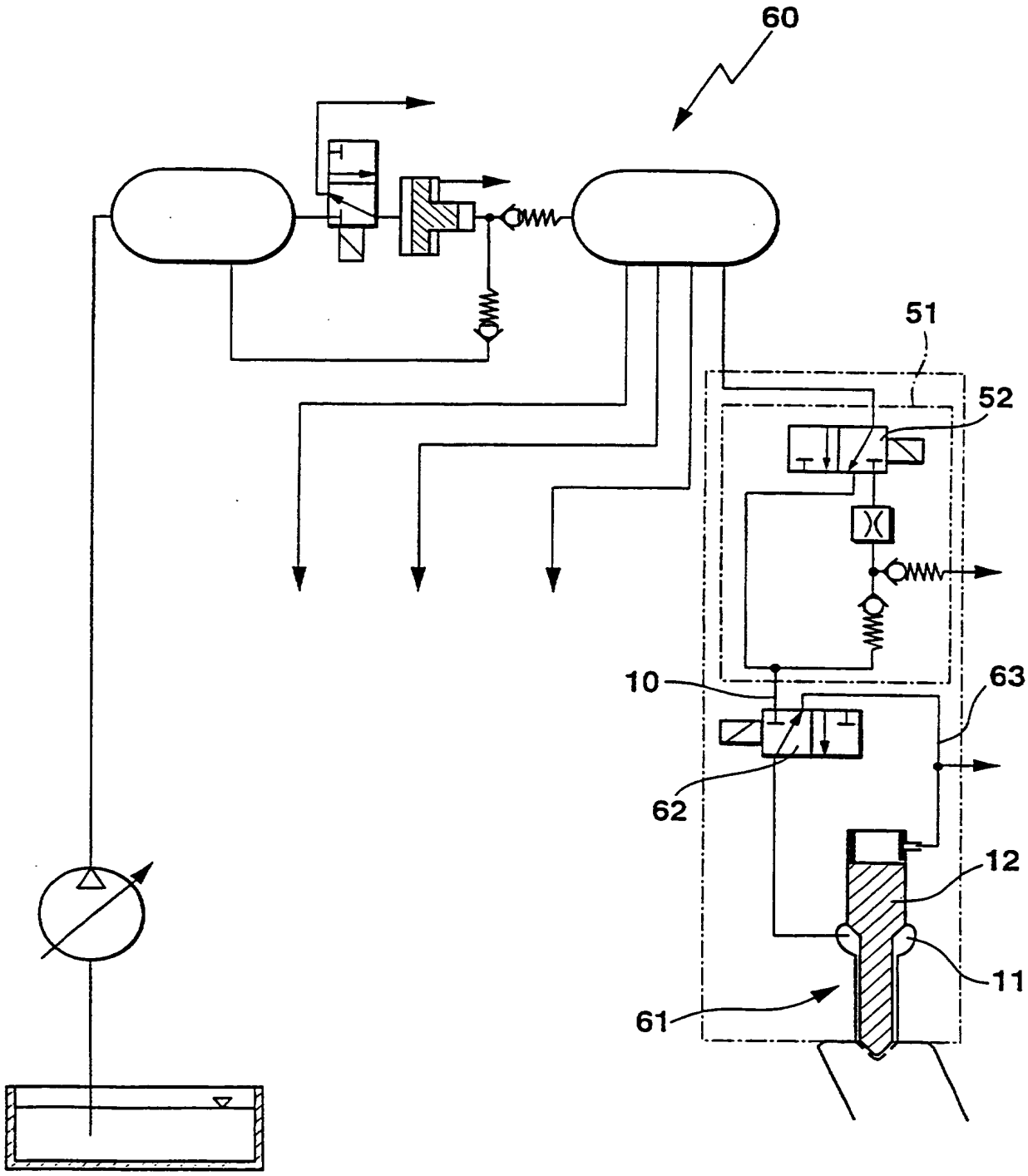


Fig. 4



DESCRIPTION

FUEL-INJECTION METHOD AND SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

The invention relates to a fuel-injection method for an internal combustion engine of the type wherein fuel is injected at at least two different high fuel pressures via injectors into the combustion chamber of an internal combustion engine, wherein the higher fuel pressure is stored in a central pressure storage device, and to a fuel-injection system of the type wherein fuel can be injected at two different high pressures via injectors into the combustion chamber of the internal combustion engine, having a central pressure storage device for the purpose of storing the higher fuel pressure.

This type of injection system has been disclosed, for example, in EP 0 711 914 A1.

In order to improve the understanding of the description hereinunder, some expressions will first be explained in more detail: In the case of a *pressure-controlled fuel-injection system* the fuel pressure prevailing in the nozzle space of an injector serves to open a valve body (e.g. a nozzle needle) against the effect of a closing force and the injection orifice is released in this way for the purpose of injecting the fuel. The pressure, at which fuel issues out of the nozzle space into the cylinder, is described as the *injection pressure*. Within the scope of the invention, the term *stroke-controlled fuel-injection system* means that the injection orifice of an injector is opened and closed with the aid of a displaceable valve member by reason of the hydraulic co-operation of the fuel pressures in a nozzle space and in a control space. Furthermore, an arrangement is described

hereinunder as being *central*, if it is provided common for all of the cylinders, and is described as being *local*, if it is only provided for one individual cylinder.

In the case of the pressure-controlled fuel-injection system which is disclosed in EP 0 711 914 A1, a high pressure pump is used to compress fuel to a first high fuel pressure of about 1200 bar and the fuel is stored in a first pressure storage device. Furthermore, the fuel which is subject to high pressure is also delivered to a second pressure storage device, in which a second high fuel pressure of ca. 400 bar is maintained by controlling its fuel supply by means of a 2 port, 2 position directional control valve. A central valve control unit and a central distributor device serve to guide either the lower or higher fuel pressure to the nozzle space of an injector where a spring-loaded valve body is raised from its seat by virtue of the pressure, so that fuel can issue out of the nozzle orifice.

In the case of this known injection system the lower fuel pressure, e.g. for the preliminary injection, cannot be metered in an optimum manner by reason of the line losses in relatively long injector supply lines.

Furthermore, a stroke-controlled injection system is disclosed in WO 98/09068, wherein two pressure storage devices are likewise provided for the purpose of storing the two fuel pressures. In this case, the respective fuel pressure is also metered via central valve units.

In accordance with a first aspect of the present invention,the lower fuel pressure is produced during the injection procedure on each occasion in a local manner for each injector individually by shutting off the higher fuel pressure, wherein the shut-off facility can be activated or deactivated via a directional control valve.

In accordance with a second aspect of the present invention, each injector is provided in each case with a local shut-off unit, by means of which the lower fuel pressure can be generated in a dissipative manner from the higher fuel pressure, wherein the local shut-off UNIT comprises a directional control valve for the purpose of activating or deactivating the shut-off facility.

Thus, it is proposed to generate the lower fuel pressure for each injector in a dissipative manner in each case locally via a shut-off unit, rather than generating the lower fuel pressure in a central manner. The short line between the local shut-off unit and the nozzle space of the injector serves to reduce line losses to a minimum. By virtue of the fact that the lower pressure is generated locally, it is not necessary to provide a second pressure storage device. Further advantages include the effective reproducibility of the preliminary and subsequent injection at the lower fuel pressure and the reduced influence of component tolerances on the preliminary and subsequent injection.

Various exemplified embodiments of fuel-injection systems in accordance with the invention, wherein the lower fuel pressure is generated in a dissipative manner for each injector individually, are explained in the description hereinunder and illustrated in a schematic manner in the accompanying drawings, in which

Figure 1 shows a first stroke-controlled fuel-injection system for an injection process at two different high fuel pressures, in each case with a local shut-off unit and a local accumulator chamber for each injector;

Figure 2 shows a second stroke-controlled fuel-injection system having a system of generating the higher fuel pressure which is modified

with respect to Figure 1;

Figure 3 shows a third stroke-controlled fuel-injection system without the local accumulator chamber, but having for each injector a local shut-off unit which is modified with respect to Figure 1; and

Figure 4 shows a fourth fuel-injection system corresponding to Figure 3, but including pressure-controlled injectors.

In the case of the first exemplified embodiment of a stroke-controlled fuel-injection system 1 as illustrated in Figure 1, a quantity-controlled high pressure pump 2 delivers fuel 3 from a storage tank 4 at high pressure via a delivery line 5 into a central pressure storage device 6 (high pressure-common rail), from which a plurality of high pressure lines 7, which correspond to the number of individual cylinders, lead off to the individual injectors 8 (injection device) which protrude into the combustion chamber of the internal combustion engine to be supplied. Figure 1 illustrates only one of the injectors 8 in detail. A first higher fuel pressure of ca. 300 bar to 1800 bar can be stored in the pressure storage device.

The higher fuel pressure provided in the high pressure line 7 is guided via a pressure line 10 into a nozzle space 11 of the injector 8 by supplying current to a 3 port, 2 position directional control valve 9. The injection at the higher fuel pressure (main-injection process) is performed with the aid of a piston-shaped valve member 12 (nozzle needle) which can be displaced in an axial manner in a guide bore and whose conical valve sealing surface 13 cooperates with a valve seat surface on the injector housing and in this way closes the injection orifices 14 provided at this site. Within the nozzle space 11, a pressure surface of the valve member 12 which points in the opening direction of the

valve member 12 is subjected to the pressure prevailing at this site, wherein the nozzle space 11 continues via an annular gap between the valve member 12 and the guide bore as far as the valve sealing surface 13 of the injector 8. The pressure prevailing in the nozzle space 11 serves to open the valve member 12, which seals the injection orifices 14, against the effect of a closing force (closing spring 15), wherein the spring chamber 16 is relieved of pressure by means of a leakage line 17. The valve member 12 is acted upon coaxially with respect to closing spring 15 by a pressure piece 18 which defines a control space 20 with its end face 19 remote from the valve sealing surface 13. From the pressure line 10, the control space 20 has a fuel inlet having a first restrictor 21 and a fuel outlet to a pressure relief line 22 having a second restrictor 23 which can be connected to a leakage line 25 by means of a control member in the form of a 2 port, 2 position directional control valve 24. The pressure in the control space 20 serves to influence the pressure piece 18 with pressure in the closing direction. By actuating (supplying current to) the 2 port, 2 position directional control valve 24, it is possible to reduce the pressure in the control space 20, so that as a consequence the pressure in the pressure chamber 11 acting upon the valve member 12 in the opening direction exceeds the pressure acting upon the valve member 12 in the closing direction. The valve sealing surface 13 rises from the valve seat surface, so that an injection is performed at the fuel pressure. The procedure of relieving the control space 20 and thus of controlling the stroke of the valve member 12 can be influenced by dimensioning the two restrictors 21, 23. The injection process will then be terminated by closing the 2 port, 2 position directional control valve 24.

When a 3 port, 2 position directional control valve 9 is being supplied with current, this injection at the higher fuel pressure (main-injection process) is performed in

a stroke-controlled manner via the 2 port, 2 position directional control valve 24. During the main-injection process, an accumulator chamber 26 which is connected in the proximity of the nozzle space 11 to the pressure line 10 is filled with the fuel subjected to the higher fuel pressure. By switching the 3 port, 2 position directional control valve 9 back to the currentless state, the main-injection process is terminated and the pressure line 10 is connected to the leakage line 25 via a pressure-limiting valve 27 which is set to a second lower fuel pressure (ca. 300 bar). The leakage line 25 serves to relieve pressure and can lead back to the storage tank 4. This switching process causes higher fuel pressure initially still prevailing in the pressure line 10, the accumulator chamber 26 and in the nozzle space 11 to fall to the lower fuel pressure. This lower fuel pressure is used for the preliminary and/or subsequent injection process (HC-enrichment for the after-treatment of exhaust gas).

When current is not being supplied to a 3 port, 2 position directional control valve 9, the injection at the lower fuel pressure stored in the accumulator chamber 26 is performed in a stroke-controlled manner by way of a 2 port, 2 position directional control valve 24, and can be performed either as a subsequent injection after the main-injection process or as a preliminary injection prior to the main-injection process. If the accumulator chamber 26 is also filled sufficiently with pressurized fuel after a subsequent injection, this fuel can be used for a preliminary injection during the next injection cycle. The size of the accumulator chamber 26 is tailored to suit the requirements of the preliminary and subsequent injection, wherein the function of the accumulator chamber 26 can also be fulfilled by an adequately dimensioned pressure line.

The local shut-off unit, which is designated as a whole in Figure 1 by 28 and

consists of the 3 port, 2 position directional control valve 9 and the pressure-limiting valve 27, can either be disposed inside the injector housing (Figure 1a) or outside (Figure 1b).

Only the differences from the fuel-injection system according to Figure 1 will be discussed hereinunder in the description of the further Figures. Identical or functionally identical components will be provided with like reference numerals and will not be explained in detail.

With the exception of the generation of the higher fuel pressure, the injection system 30 illustrated in Figure 2 corresponds to the injection system 1. The high pressure pump 2 delivers fuel to a first central pressure storage device 31 (low pressure common-rail). The fuel stored at this site at a pressure of ca. 300 to 1000 bar is compressed by means of a central pressure intensification unit to the higher fuel pressure (ca. 600 to ca. 2000 bar) and is stored in the second central pressure storage device 6. The pressure intensification unit comprises a valve unit 32 for the purpose of controlling the pressure intensification, a pressure intensifier 33 having a pressure means 34 in the form of a displaceable piston element and two non-return valves 35 and 36. The pressure means 34 can be connected at one end to the first pressure storage device 31 with the aid of the valve unit 32, so that said pressure means is influenced at one end with pressure by virtue of the fuel located in a primary chamber 37. A differential chamber 38 is relieved of pressure by means of a leakage line 39, so that the pressure means 34 can be displaced in the direction of compression for the purpose of reducing the volume of a pressure chamber 40. As a consequence, the fuel located in the pressure chamber 40 is compressed to the higher fuel pressure according to the surface ratio of the primary chamber 37 and

the pressure chamber 40 and said fuel is supplied to the second pressure storage device 6. The non-return valve 35 prevents the return flow of compressed fuel from the second pressure storage device 6. If the primary chamber 37 is connected to a leakage line 41 with the aid of the valve unit 32, then the pressure means 34 is returned to its position and the pressure chamber 40, which is connected to the first pressure storage device 61 via the non-return valve 36, is refilled. The pressure ratios in the primary chamber 37 and in the pressure chamber 40 cause the non-return valve 36 to open, so that the pressure chamber 40 is subjected to the fuel pressure of the first pressure storage device 61 and the pressure means 34 is returned in a hydraulic manner to its starting position. In order to improve the manner in which the pressure means is returned to its position, one or several springs can be disposed in chambers 37, 38 and 40. In the illustrated exemplified embodiment, the accumulator chamber 36 is disposed in the pressure line 10 between the local shut-off unit 28 and the inlet to the control space 20 and the valve unit 32 is illustrated merely by way of example as a 3 port, 2 position directional control valve.

In contrast to the injection system 30, the injection system 50 in Figure 3 comprises a modified local shut-off unit 51 and no accumulator chamber. The shut-off unit 51 comprises a 3 port, 2 position directional control valve 52, in order either to switch through the higher fuel pressure stored in the second pressure storage device 6 or to shut said fuel off in a dissipative manner by means of a restrictor 53 and a pressure-limiting valve 55 which is set to the lower fuel pressure and is connected to a leakage line 54. The respectively available pressure is then guided further as in Figure 1 via the pressure line 10 to the stroke-controlled injector 8, wherein a non-return valve 56 prevents the higher fuel pressure from flowing away via the non-return valve 55.

The injection system 60 (Figure 4) which otherwise corresponds to the injection system 50 uses pressure-controlled injectors 61, wherein the valve member 12 is opened merely by means of the higher or lower fuel pressure prevailing in each case in the nozzle space 11. The fuel pressure provided in each case downstream of the local shut-off unit 51 is switched through by means of a 3 port, 2 position directional control valve 62 disposed in the pressure line 10. A preliminary or subsequent injection at the lower fuel pressure is performed when a 3 port, 2 position directional control valve 52 and a 3 port, 2 position directional control valve 62 are being supplied with current. If the 3 port, 2 position directional control valve 52 is switched back to the currentless state, it is possible to switch over to an injection at the higher fuel pressure. At the end of the main-injection process, it is possible to supply current once again to the 3 port, 2 position directional control valve 52 either for a subsequent injection at the lower fuel pressure, or the 3 port, 2 position directional control valve 62 is switched back to leakage 63. As a consequence, the pressure line 10 and the nozzle space 11 are relieved of pressure, so that the spring-loaded valve member 12 then closes the injection orifices 14.

In the case of injecting fuel at at least two different high fuel pressures via injectors 8 into the combustion chamber of an internal combustion engine, wherein the higher fuel pressure is stored in a central pressure storage device 6, the lower fuel pressure is produced during the injection procedure on each occasion in a local manner for each injector 8 individually by shutting off the higher fuel pressure, wherein the shut-off facility can be activated or deactivated by way of a directional control valve. To this end, a corresponding fuel-injection system 1 having a central pressure storage device 6 for the

purpose of storing the higher fuel pressure comprises for each injector 8 in each case a local shut-off unit 28, by means of which it is possible to generate in a dissipative manner the lower fuel pressure from the higher fuel pressure, wherein the local shut-off unit 28 comprises a directional control valve 9 for the purpose of activating or deactivating the shut-off facility. In this way, it is possible to meter the lower fuel pressure in an improved manner.

CLAIMS

1. A method of injecting fuel at at least two different high fuel pressures via injectors into the combustion chamber of an internal combustion engine, wherein the higher fuel pressure is stored in a central pressure storage device, the lower fuel pressure is produced during the injection procedure on each occasion in a local manner for each injector individually by shutting off the higher fuel pressure, and the shut-off facility can be activated or deactivated via a directional control valve.

2. A fuel-injection system for an internal combustion engine, wherein fuel can be injected at two different high pressures via injectors into the combustion chamber of the internal combustion engine, having a central pressure storage device for the purpose of storing the higher fuel pressure, and for the purpose of implementing an injection method according to claim 1, wherein each injector is provided in each case with a local shut-off unit, by means of which the lower fuel pressure can be generated in a dissipative manner from the higher fuel pressure, the local shut-off unit comprising a directional control valve for the purpose of activating or deactivating the shut-off facility.

3. A fuel-injection system according to claim 2, wherein the local shut-off unit comprises a pressure-limiting valve.

4. A fuel-injection system according to claim 3, wherein the pressure-limiting valve is disposed between the directional control valve and a nozzle space of the injector.

5. A fuel-injection system according to claim 4, wherein a restrictor is provided between the directional control valve and the pressure-limiting valve.

6. A fuel-injection system according to claim 3, wherein the pressure-limiting valve is disposed on the leakage-side downstream of the directional control valve.

7. A fuel-injection system according to any of claims 2 to 6, wherein upstream of the central pressure storage device for the higher fuel pressure there is provided at least one further pressure storage device having a pressure intensification unit connected downstream.

8. A fuel-injection system according to claim 7, wherein the pressure intensification unit comprises at least one pressure means having a refill-arrangement.

9. A fuel-injection system according to any of claims 2 to 8, wherein the local shut-off unit is integrated in the injector.

10. A fuel-injection system according to any of claims 2 to 8, wherein the local shut-off unit is provided in the region of the central pressure storage device for the higher fuel pressure.

11. A fuel-injection system according to any of claims 2 to 8, wherein the local shut-off unit is disposed at any point between the central pressure storage device for the higher fuel pressure and the nozzle space of the injector.

12. A fuel-injection system according to any of claims 2 to 11, wherein the injectors are formed for the purpose of controlling the pressure.

13. A fuel-injection system according to any of claims 2 to 11, wherein the injectors are formed for the purpose of a stroke-controlling process.

14. A method of injecting fuel at at least two different high fuel pressures via injectors into the combustion chamber of an internal combustion engine, substantially as hereinbefore described with reference to the accompanying drawings.

15. A fuel injection system substantially as hereinbefore described with reference to and as illustrated in the accompanyiong drawings.

Application No: GB 0020025.3
Claims searched: 1 to 15

Examiner: John Twin
Date of search: 6 November 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F1B (B2JCN)

Int Cl (Ed.7): F02M 45/00

Other: online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 459429 A1	(Toyota)	1,2 at least
X	EP 195736 A	(Stanadyne) - see eg p.8, line 31 - p.9, line 15	1,2 at least
X	JP 3-225063 A	(Aisan) - see Patent Abstracts of Japan, vol.015513, group M1196	1,2 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.